United States Department of Agriculture
Rural Electrification Administration

March 11, 1953

STATUS REPORT

OVERVOLTAGES ON 14.4/24.9 KV SYSTEMS

I. Purpose:

The purpose of this status report is to briefly present the details of a steady state overvoltage condition which may be as high as two to three times normal on 14.4/24.9 kv systems and a recommendation for its solution.

II. Background Information:

A. Reports of excessive lightning arrester failures on 14.4/24.9 kv systems were received from a number of sources. In addition, scattered reports were received of secondary meter damage not attributable to the usual natural causes. Similar observations of phenomena from different sources indicated that equipment damage was caused by voltage much higher than normal line-to-ground voltage. A study including field measurements was conducted to determine the cause and a solution of this problem.

III. General:

A. A steady state voltage of from two to three times normal line-to-ground voltage has probably occurred on portions of most three-phase 14.4/24.9 kv systems. It may be established on the unenergized phase or phases when one or two lines feeding an unloaded ungrounded wye-delta three-phase transformer installation are opened. It may occur when one or two of the fuse cutouts at the installation are opened or when the opening is at any point between the source and the bank. However, single-phase loads on the unenergized phase or phases will reduce the magnitude or prevent this high voltage from establishing itself. A surge of voltage causing the lightning arrester to flashover normally precedes the establishing of the high steady state voltage.

IV. Equipment Damage:

A. Lightning arresters have been damaged by the high sustained voltage. The high voltage forces leakage current through the arrester. This current damages the fiber tube and heats the external gap causing the metal adjacent to the gap to form in small beads. Lightning arresters may have been damaged so that they are not able to interrupt power follow current. Where this damage has occurred external gap electrodes will be pitted.

B. Secondary meters have been destroyed. Test results indicate that the initial surge of voltage is transformed to the secondary and breaks down the meter insulation. The 480 volt meters are especially susceptable because power follow current is likely after a voltage surge has initiated current flow through the insulation. The steady state overvoltage on the secondary may be as high as one and one half times normal.

C. Reclosers and transformers are protected from the overvoltage to some extent by the lightning arresters. However, the steady state overvoltage can be a contributing cause of failure to these items.

V. Cause of High Voltage:

A. The high voltage is produced by the energized phase or phases feeding current through the unenergized transformer and then to ground through the inherent line-to-ground capacitance of the conductor, insulators, and other associated equipment back to the opening point. The circuit is naturally resonant and can result in high voltage being established.

VI. How to Check for High Voltage:

A. A check of the high voltage condition on any particular line can most readily be made by opening the line at an unloaded ungrounded wye-delta transformer installation. If overvoltages are present the opening surge voltage associated with the establishment of a steady state overvoltage will normally cause the arrester on the open phase to spill over once or twice during a series of four or five openings. The condition is somewhat aggravated when the second line is deenergized and more so when there is a few hundred feet of unloaded line beyond the opening point. When checking for high voltage by opening at the three-phase transformer installation, the line should be deenergized at a point which will keep the arresters on the load side of the opening point.

VII. Remedy:

A. The solution that appears most satisfactory for eliminating overvoltages on present installations and preventing them on new installations is to connect three-phase load banks grounded wye-grounded wye. The possibility of triple harmonics causing difficulty with adjacent communication circuits has been given careful study. The increase in harmonic exciting currents due to the grounded wye-grounded wye connection will not usually be significant on these systems.

B. The "Vee" connection can be a solution for banks of 50 kva capacity and below.

CAUTION: Grounding the wye of an ungrounded wye-delta bank should not be used as a solution because of the danger of transformer burnout during line-to-ground faults.

VIII. Voltage Limits of Grounded Wye-Grounded Wye:

A. The grounded wye-grounded wye transformer connection will deliver a nominal 120/208 volts on a four wire wye secondary. Voltage limits for line-to-ground voltage at the utilization point have previously been specified as 107 minimum to 127 maximum. Line-to-line voltage limits at the utilization point for satisfactory operation of three-phase motors is 198-242 volts. For satisfactory operation of three-phase motors and single-phase load from the same three-phase bank, voltage at the utilization point should be held between 114/198 minimum to 127/220 maximum. Transformer taps should not be changed to obtain a line-to-line secondary voltage higher than the nominal 208 volts since boosting the taps will cause an increase in core loss due to over excitation of the transformers.

B. Many single-phase motors are rated 115/230 volts. The nominal 208 volt line-to-line secondary will not serve the 230 volt winding adequately. Usually the motor can be reconnected for operation at 115 volts and served at the nominal 120 volts. If it is not practical to serve single-phase motors at 120 volts because of secondary wire size considerations, a separate transformer can be used for single-phase service. "Vee" phase connection with the nominal 120/240 volt three wire secondary is an alternative when total transformer capacity is 50 kva or less.

IX. Metering of Grounded Wye-Grounded Wye:

A. Metering of the four wire wye secondary will require a different meter than that used on the four wire delta secondary. A three element wye meter, with potential coils rated for phase to neutral voltage, will be required for the four wire wye circuit.

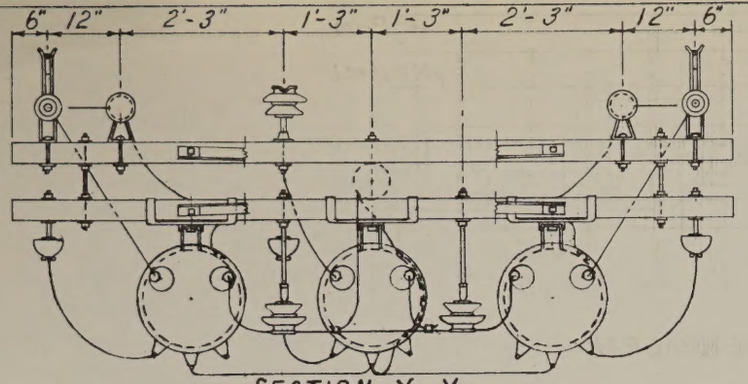
B. On three wire, three-phase, motor loads (where no power connections are made to the neutral) the identical two element meter is used on both wye and delta circuits. Reconnection is not necessary. Recalibration for the reduced phase to phase voltage is not necessary.

C. It may be desirable to meter the two or three wire house service separately from a motor service, both being supplied from a four wire wye secondary. If this is the case, the following meter applications are correct.

1. Two wire, 120 volt house service -- The standard two wire, 120 volt single-phase meter is correct.

2. Three wire, 120/208 volt, house service (two phase wires and secondary neutral) -- This service will require a 120 volt, two element, meter. This type of service is commonly called "network" and cannot be properly metered by any single-phase three wire meter.

Further investigations on this problem are being made and a more complete technical report on this subject will be prepared. In the meantime any questions on this problem should be referred to the area office.



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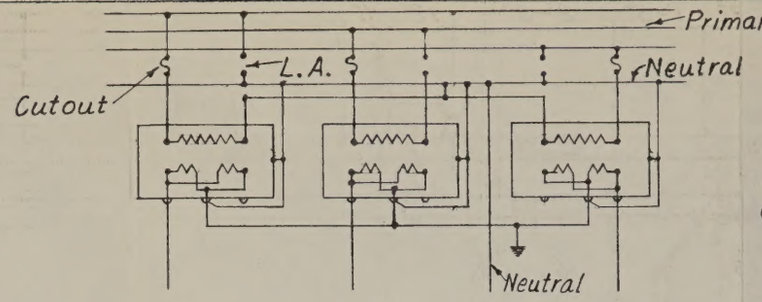


WIRING DIAGRAM

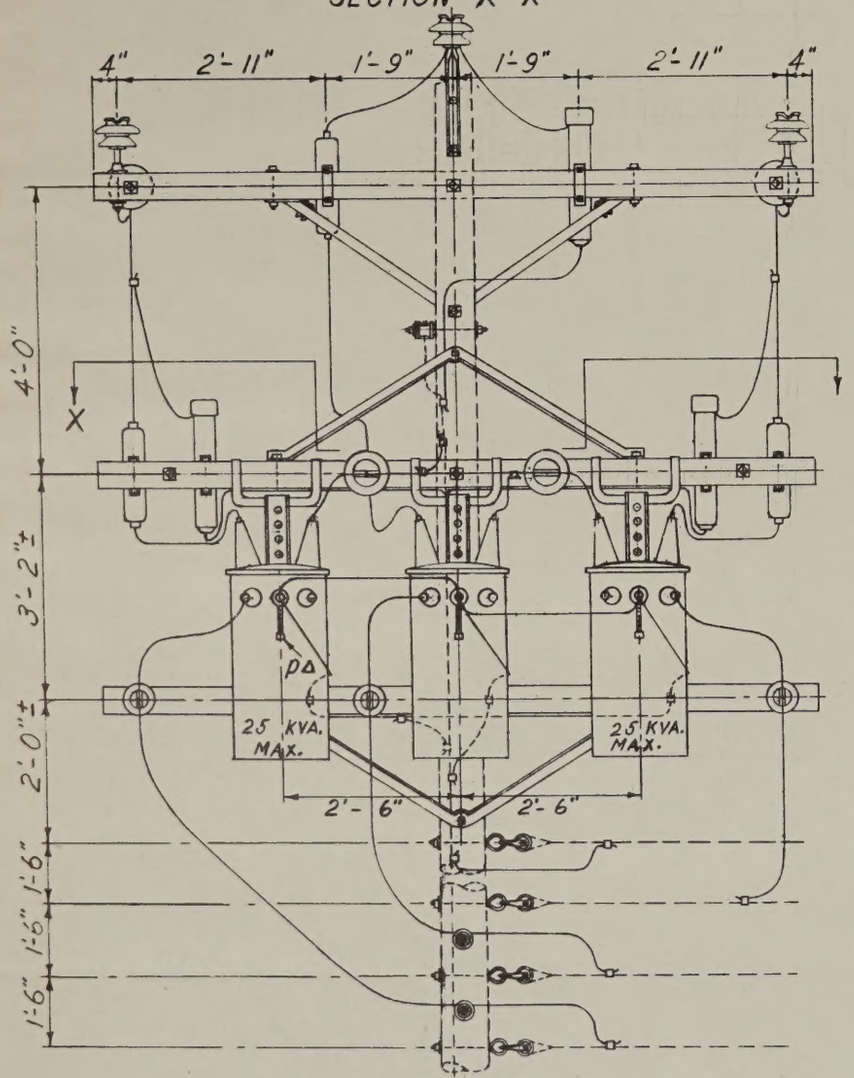
The following changes are necessary to operate the 3-phase transformer installation shown in drawing D-3482 (VG315-5) as grounded Wye - grounded Wye.

1. Change internal secondary connections of all transformers in order to parallel the secondary windings as shown in wiring diagram.

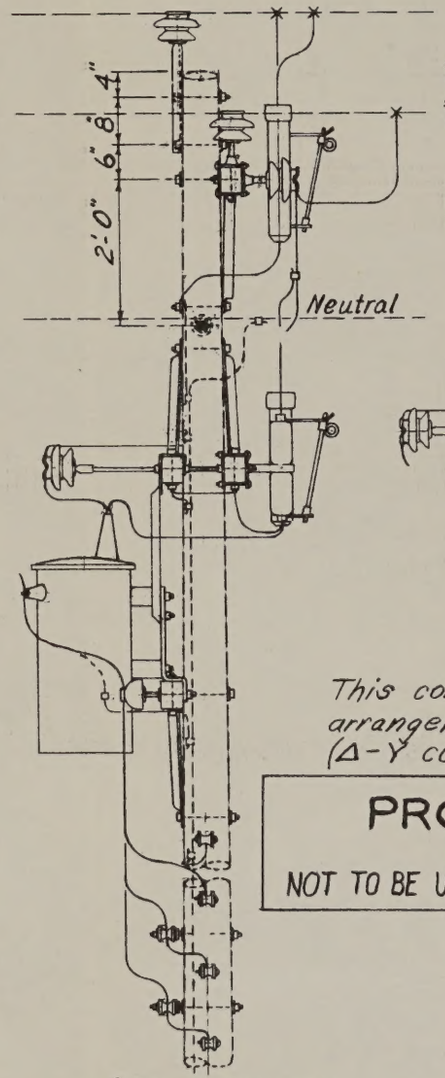
2. Provide a jumper from the present ungrounded neutral to the pole ground wire.

3. Provide a connection between all secondary neutral bushings and a ground connection (jumper) from each secondary neutral bushing to respective transformer ground stud. In addition to this connect all secondary neutral bushings to the tanks.

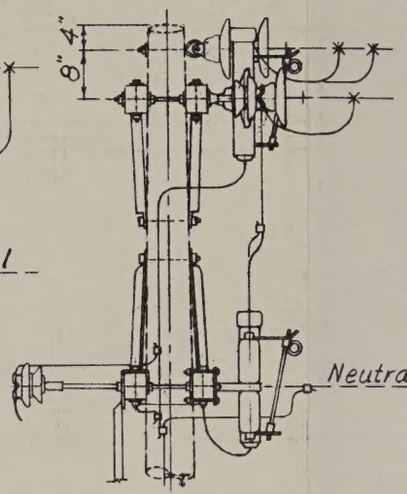
4. Attention is called to the difference in metering requirements for grounded Wye - grounded Wye connections.



ELEVATION



SIDE ELEVATION



This conversion to be used only where the present arrangement according to drawing D-3482 (Δ-Y connection) may result in excessive overvoltage.

PROPOSED

NOT TO BE USED FOR CONSTRUCTION

14.4/24.9 KV. PRIMARY, 3-PHASE, 4-WIRE
CONVERSION FROM UNGROUNDED WYE-DELTA TO GROUNDED WYE - GROUNDED WYE

Scale: ½"=1'-0"

Date: Oct. 10, 1952

B-3558